PASSAGE OF SALMONOIDS THROUGH A DARKENED FISHWAY

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PASSAGE OF SALMONOIDS THROUGH A DARKENED FISHWAY

by

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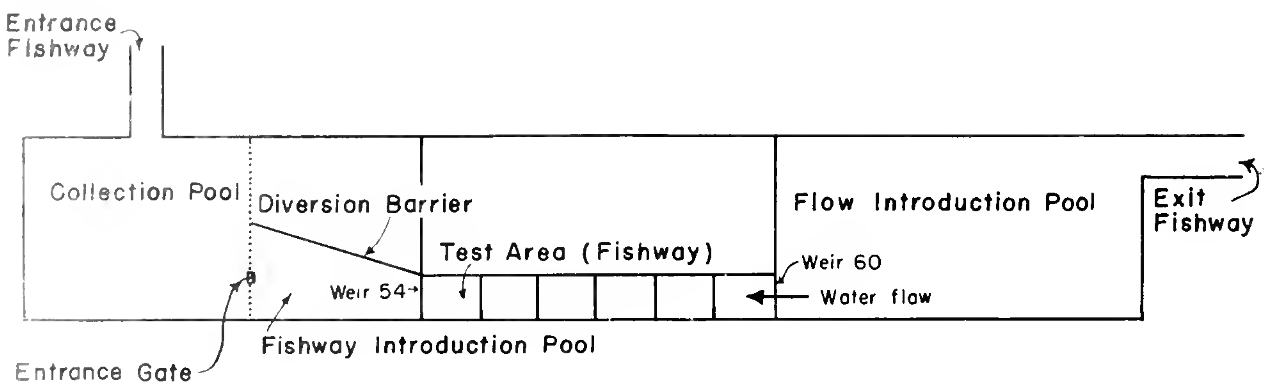

Figure 1.--Sketch showing principal units of research facility in plan view.

PASSAGE OF SALMONOIDS THROUGH A DARKENED FISHWAY 1/

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ABSTRACT

An experiment to produce specific information on rate of ascent of salmonoids through a darkened fishway was conducted in a short, pool-and-overfall fishway without submerged orifices. The fish (98 percent steelhead - Salmo gairdneri) negotiated the 6-pool fishway significantly faster in near-total darkness than in light conditions approximating a bright, cloudy day.

INTRODUCTION

In the construction of fishways, occasionally it is necessary to provide covering to protect against slides and debris. Also, it is not uncommon to find fishway channels covered for roadway crossings, decking, and other purposes. Such situations may result in dimly lighted fishway channels, some of which have been provided with artificial lighting to simulate natural light prevailing in outside fishways.

Whether or not artificial lighting is necessary or even desirable, has not been fully demonstrated. Although experiments at Bonneville Dam (U. S. Army, Corps of Engineers, 1948) indicated that under suitable hydraulic conditions salmonoids will pass through a darkened fishway, specific information on rate of ascent was not obtained.

To provide answers to these questions, an experiment designed to measure the effect of total or near-total darkness on the passage of adult migrating salmonoids through a pool-and-overfall fishway was conducted. Steelhead (Salmo gairdneri) comprised 98 percent of those fish tested.

FISHWAY

The experiment was conducted in the Fisheries-Engineering Research Facility which adjoins the Washington shore fishway at Bonneville Dam on the Columbia River. A by-pass diverts a part of the Washington shore fishway flow through the facility and back into the fishway again. Each day a portion of adult salmonoids moving up the Washington fishway were diverted into the facility, and after passing through the experimental area, they continued their movement in the by-pass until they again entered the main fishway. Figure 1 shows schematically the elements of the facility (described by Collins 2/) essential to the description of this experiment: namely, the collection pool in which the test fish accumulated, the fishway introduction pool into which the fish were released, the test area (fishway), and the flow introduction pool into which the fish passed after ascending the fishway.

The test area was a pool-and-overfall-type fishway without submerged orifices. The fishway was 4 feet wide by 96 feet long, and consisted of six 16-foot pools with a 1-foot rise between pools. Because of the sloped floor, water depth in each pool varied from 6.8 feet in the lower end to 5.8 feet

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1/ Research financed by the U. S. Army Corps of Engineers as a part of a broad program of fisheries-engineering research for the purpose of providing design criteria for more economical and more efficient fish passage facilities at Corps projects on the Columbia River.

2/ Gerald B. Collins. Research in fish passage problems. U. S. Fish and Wildlife Service. Manuscript in preparation.

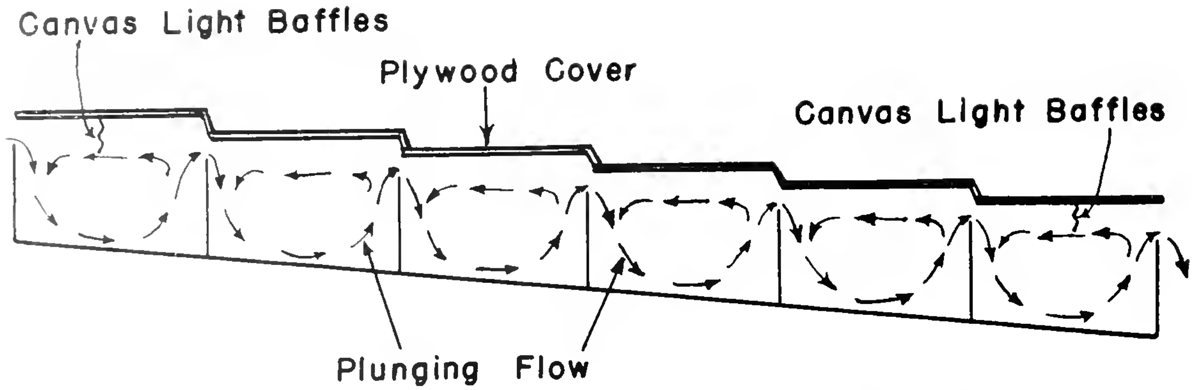

Figure 2.—Schematic illustration of test area (fishway) showing plywood cover, canvas baffles, and plunging flow pattern in side view.

in the upper end. Square crested weirs 7 1/2 inches wide were painted white on top to facilitate observing the fish as they passed in and out of the fishway. The head on each weir, measured four feet upstream of the weir, was 0.8 foot. The flow pattern was that generally described as "plunging flow" (figure 2).

For the "dark" or test trials, the fishway was covered with plywood sheets and sealed with canvas strips (figure 3). To reduce the light entering the entrance and exit of the resulting fishway tunnel, canvas baffles were extended from the plywood cover to within two inches of the water surface in the center of both first and last pools (figure 2). To further reduce the light entering the fishway the laboratory was darkened.

Light readings yielded values of 0.1 foot candle in the collection pool near the entry gate (figure 1), and 0.01 and 0.02 foot candle at the first weir of the fishway (the upstream end of the introduction pool) and at the last weir of the fishway. Visual observations made in the central portion of the fishway indicated insufficient light to register in the human eye.

For the "light" or control trials, the plywood covering was removed and 1000-watt mercury-vapor lamps were suspended six feet above the fishway (figure 4) and six feet apart (measured center to center) down the center of the fishway. These lamps provided light intensities at the surface of the fishway pools ranging from 300 foot candles measured along the wall to 1000 foot candles directly beneath the lights. This range of light intensities approximates outdoor conditions on a bright, cloudy day.

Water temperatures varied from 65.5° F. to 66.0° F. on the two days the experiment was conducted--July 23 and 24, 1957. Turbidimeter and Secchi's disc readings yielded values of 10 (equal to 10 p.p.m. SiO_2) and 4.5 feet respectively on both days.

PROCEDURE

The experiment consisted of four control and four tests trials. As only one fishway was used, the control and test trials were conducted alternately. Averages of 26 and 21 fish were utilized for each control and test trial respectively. The species composition for the four groups passed under the dark (test) condition was 82 steelhead and 1 chinook, and for the four groups passed under the light (control) condition, 100 steelhead and 3 chinook.

About 10 to 15 minutes before beginning a test trial, we darkened the building to permit the observers to adapt their eyes to the limited light. At the end of this time, the observers could count the fish as they passed through the entry gate and over the white weir crests of the fishway.

An observer stationed at the collection pool initiated each test and each control trial by opening the entrance gate.

Figure 3.--The dark fishway (on right) showing plywood and canvas covering. Building interior was darkened during trials.

Figure 4.--The lighted fishway. Upper five pools of fishway are shown on extreme right.

The fish were then allowed to pass through the gate and commence their ascent of the fishway. When an adequate sample of fish had entered, the entrance gate was closed. Each trial was terminated when all fish entered had passed through the fishway.

The opening of the entrance gate signaled the start of each trial. Observers stationed at the first weir (54 [3/]) and the last weir (60 [3/]) were equipped with push-button switches that activated recording pens in an operations recorder. The moment a fish passed weir 54 or weir 60 the corresponding switch was pressed and a recording pen marked the time of passage (as related to the start) on a continuous paper tape.

3/ The numbers 54 and 60 refer to the elevation of the weir crests in feet above mean sea level.

RESULTS AND DISCUSSION

The results of the four control and four test trials are presented in figure 5 (see Appendix 1 for original data). The median entry (at weir 54) and median exit (at weir 60) times for the grouped control (n = 103) and grouped test trials (n = 83) correspond to the intersection of the median or 50 percent line and the respective cumulative percent lines. Examination of these median times reveals two main points: (1) the fish were slower in entering the fishway under the dark condition than under the light condition, as evidenced by the difference in the respective median entry times at weir 54,aand (2) the length of time

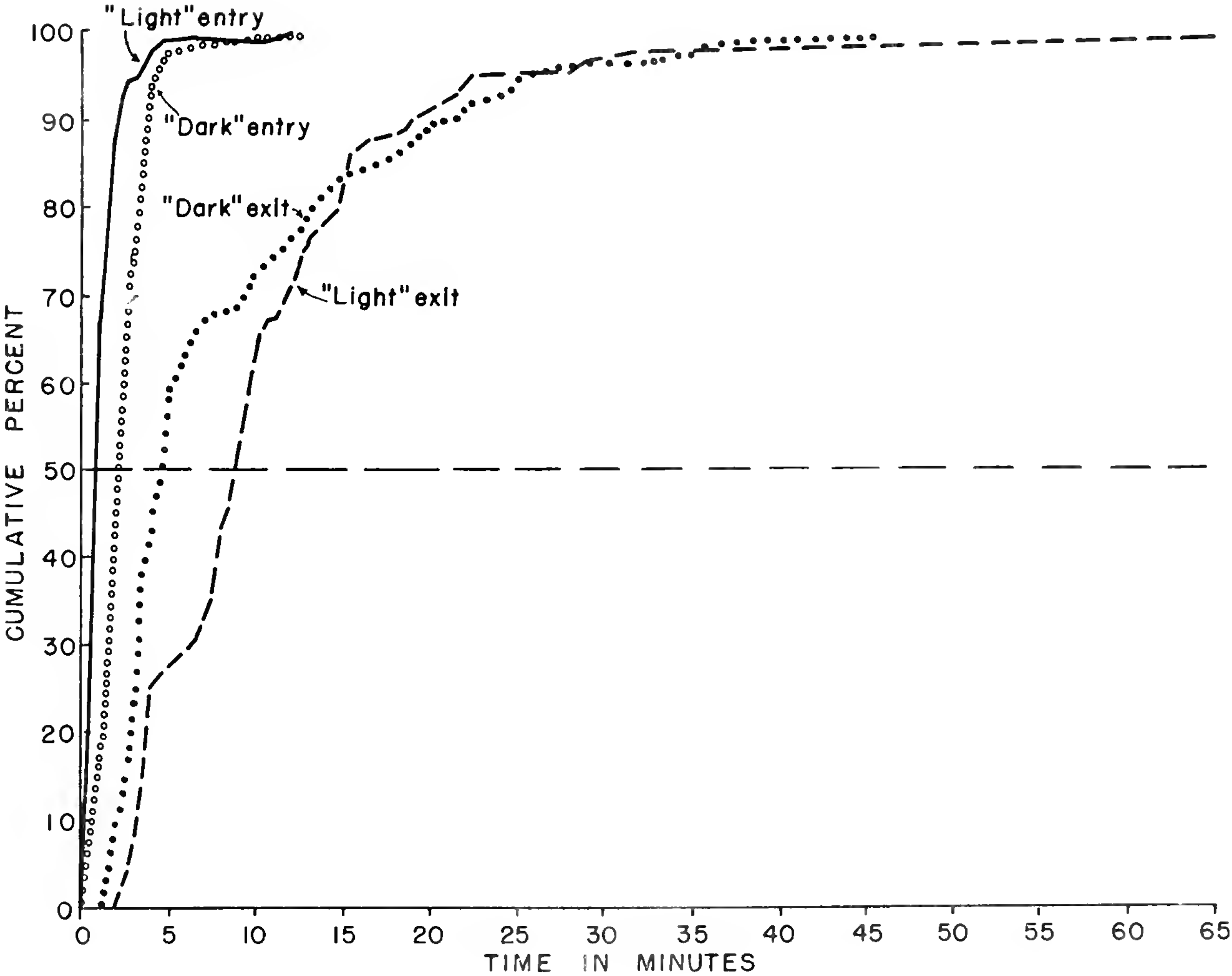

Figure 5.--Cumulative entry and exit (percent) in minutes during light and dark fishway trials.

(median elapsed time) [4/] required by the fish to negotiate the fishway was less under the dark than under the light condition.

The slower median entry time at weir 54 under the dark condition can be at least partially explained by the fact that the fish were observed to hesitate more before passing through the small entrance gate (10 inches wide) in the dark condition than in the light.

Table 1 lists the median elapsed times for the four control and four test trials. The average median elapsed time under the dark condition was 2.0 minutes and the average median elapsed time under the light condition was 8.5 minutes. A "t" test indicates that passage through the fishway was significantly faster in the dark condition.

Table 1.--Summary of light and dark fishway trials showing effect of lighting condition upon passage time.

	Condition			
	Light		Dark	
Trial number	N	Median elapsed time (minutes)	N	Median elapsed time (minutes)
1	30	6.13	22	1.28
2	24	7.32	19	2.18
3	23	11.93	20	2.75
4	26	8.53	22	1.78

The degree to which the results of this limited experiment may be safely applied is a matter of conjecture. Additional experiments are necessary to determine the relationship between fishway dimension and design and the degree to which the behavior of salmonoids is affected by low light intensities. As the present experiment applies almost exclusively to steelhead, it will be of interest to examine the behavior of other salmonoids under similar test conditions.

4/ The median elapsed time is defined as the difference between the median entry (at weir 54) and median exit (at weir 60) time.

SUMMARY

The experiment was designed to determine the effect of low light intensities upon the rate of passage of adult migrating salmonoids through a pool-and-overfall-type fishway without submerged orifices. The fishway, 4 feet wide by 96 feet long, consisted of six 16-foot pools with a 1-foot rise between pools. Average water depth in the pools was 6.3 feet and the head on each weir was 0.8 foot.

The fishway was darkened for four test trials and lighted for four control trials. A total of 82 steelhead and 1 chinook were passed through the darkened fishway and 100 steelhead and 3 chinook through the lighted fishway. Light measurements taken during the dark condition yielded values between 0.1 foot candle downstream of the fishway and near-total darkness in the central portion of the fishway. Light readings taken at the surface of the fishway pools during the lighted condition yielded values ranging from 300 to 1000 foot candles.

The average median elapsed passage time through the dark fishway was 2.0 minutes and through the light fishway 8.5 minutes. A significantly faster rate of passage through the dark fishway is indicated.

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APPENDIX

Table 2.--Entry and exit observations (time in minutes from start) of fish passage during light and dark fishway conditions, trial number 1, July 23, 1957.

Observation number	Light fishway (control)		Dark fishway (test)	
	Entry time (Weir 54)	Exit time (Weir 60)	Entry time (Weir 54)	Exit time Weir 60)
1	0.25	1.77	0.33	1.46
2	0.30	2.22	0.52	2.23
3	0.32	2.60	0.75	2.50
4	0.33	3.15	1.03	2.83
5	0.35	3.25	1.18	3.13
6	0.37	3.38	1.40	3.25
7	0.38	3.46	1.63	3.32
8	0.46	3.50	1.92	3.37
9	0.46	3.80	1.97	3.73
10	0.48	3.83	2.30	4.00
11	0.50	3.90	2.70	4.23
12	0.57	4.46	2.72	4.58
13	0.60	4.57	2.75	4.67
14	0.67	6.12	2.77	4.82
15	0.68	6.80	2.77	5.13
16	0.70	6.83	3.46	6.28
17	0.77	7.73	3.60	12.46
18	0.80	7.78	3.63	13.68
19	0.87	8.83	3.83	21.10
20	0.90	8.87	4.02	23.90
21	0.93	8.92	4.30	27.67
22	1.20	9.07	12.30	45.17
23	1.43	9.87		
24	1.53	11.07		
25	1.65	14.60		
26	1.78	15.10		
27	1.98	22.50		
28	2.32	29.00		
29	2.70	64.58		
30	4.13	64.75		

Table 3.--Entry and exit observations (time in minutes from start) of fish passage during light and dark fishway conditions, trial number 2, July 23, 1957.

Observation number	Light fishway (control)		Dark fishway (test)	
	Entry time (Weir 54)	Exit time (Weir 60)	Entry time (Weir 54)	Exit time (Weir 60)
1	0.18	2.02	0.25	1.05
2	0.20	2.05	0.73	1.83
3	0.28	2.57	0.77	2.77
4	0.37	2.73	1.02	4.00
5	0.38	2.90	1.13	4.30
6	0.42	3.27	1.93	4.43
7	0.46	3.82	2.23	4.52
8	0.48	3.85	2.53	4.97
9	0.52	5.40	2.67	5.22
10	0.53	5.53	2.87	5.43
11	0.58	7.18	2.98	5.68
12	0.58	7.90	3.03	8.83
13	0.68	8.00	3.05	9.18
14	0.73	8.02	3.07	10.13
15	0.75	8.82	3.50	11.38
16	0.78	9.53	3.78	11.43
17	0.92	9.77	3.90	12.28
18	1.63	9.80	3.92	13.38
19	1.78	11.72	4.57	14.73
20	1.92	13.53		
21	1.93	15.03		
22	2.03	15.15		
23	3.63	17.60		
24	10.13	20.46		

Table 4.--Entry and exit observations (time in minutes from start) of fish passage during light and dark fishway conditions, trial number 3, July 23, 1957.

Observation number	Light fishway (control)		Dark fishway (test)	
	Entry time (Weir 54)	Exit time (Weir 60)	Entry time (Weir 54)	Exit time (Weir 60)
1	0.28	3.63	0.25	1.72
2	0.32	6.27	0.63	2.17
3	0.50	6.72	0.87	2.28
4	0.50	7.37	0.93	2.55
5	0.53	7.43	0.97	3.05
6	0.68	7.50	1.33	3.12
7	0.73	9.12	1.35	3.33
8	0.88	9.18	1.42	3.33
9	0.97	10.18	1.46	3.35
10	0.98	10.48	1.55	3.40
11	1.00	11.55	1.65	4.77
12	1.02	12.95	1.67	5.00
13	1.13	12.98	1.72	5.92
14	1.20	13.12	1.90	6.40
15	1.23	14.60	2.58	9.27
16	1.40	14.75	3.25	9.63
17	1.50	15.18	3.37	18.10
18	2.45	18.03	3.63	19.78
19	2.46	18.83	3.70	21.53
20	2.48	20.46	4.12	21.73
21	3.15	21.97		
22	3.43	27.55		
23	3.60	34.08		

Table 5.--Entry and exit observations (time in minutes from start) of fish passage during light and dark fishway conditions, trial number 4, July 24, 1957.

Observation number	Light fishway (control)		Dark fishway (test)	
	Entry time (Weir 54)	Exit time (Weir 60)	Entry time (Weir 54)	Exit time (Weir 60)
1	0.25	1.82	0.25	1.10
2	0.30	3.32	0.30	1.83
3	0.32	3.37	0.52	1.90
4	0.32	3.83	0.98	2.37
5	0.33	3.97	1.05	2.53
6	0.33	3.98	1.40	2.70
7	0.35	6.70	1.42	2.82
8	0.37	7.57	1.46	3.08
9	0.37	7.67	1.57	3.23
10	0.42	8.32	1.62	3.37
11	0.48	8.57	1.95	3.57
12	0.57	8.72	1.97	3.90
13	0.58	8.90	1.98	4.15
14	0.63	9.37	2.07	5.37
15	0.72	9.50	2.15	7.50
16	0.82	9.60	2.23	12.62
17	0.85	10.42	2.30	15.52
18	0.85	10.70	2.32	18.20
19	0.95	11.77	2.58	19.30
20	0.97	12.13	3.10	24.78
21	1.05	12.27	3.50	33.27
22	1.25	12.70	6.00	36.48
23	1.32	14.30		
24	1.45	14.45		
25	1.80	16.02		
26	9.33	21.03		

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